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EXECUTIVE SUMMARY

SCAR initiates, develops, and co-ordinates high quality international scientific research in the Antarctic region, and on the role of the Antarctic region in the Earth system. SCAR adds value to national research by enabling researchers to tackle issues of pan-Antarctic scale or global reach. SCAR also provides objective and independent scientific advice on issues affecting the management of the environment to the Antarctic Treaty Consultative Meeting (ATCM); the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR); and the Advisory Committee of the Agreement on Conservation of Albatrosses and Petrels (ACAP). During 2006, SCAR's main focus was on the XXIXth SCAR Meeting and 2nd Open Science Conference, hosted in Hobart, Tasmania, by the Australian Antarctic Division, which attracted 850 participants.

Through 2006, SCAR continued to focus on research in five main thematic areas: (i) the modern ocean-atmosphere-ice system; (ii) the evolution of climate over the past 34 million years since glaciation began; (iii) the response of life to change; (iv) preparations to study subglacial lakes and their environs; and (v) the response of the Earth's outer atmosphere to the changing impact of the solar wind at both poles. Particular highlights include the following:

- the Antarctic plateau has been shown to be the best place on Earth for surface-based astronomy – future plans call for possible installation of a terahertz telescope at Dome A, and a 2.4-metre optical/IR telescope at Dome C.
- advanced numerical models show that intermediate depths in the Southern Ocean have warmed by 0.2°C, and would have warmed by twice as much but for the masking effect of aerosols including volcanic dust.
- analysis of climate models suggests that by 2100 the marginal ice zone will warm in winter by up to 0.6°C/decade, resulting in a decrease of 25% in sea-ice cover; central Antarctica will warm at 0.4°C/decade in all seasons; precipitation will increase 3.3mm/decade on average over the continent, mostly around the edges; westerly winds will strengthen over the ocean, mostly in autumn, but coastal easterlies will decrease; katabatic winds will decrease slightly as temperatures on the polar plateau rise by several degrees.
- drilling through the Ross Sea ice shelf shows that the shelf has come and gone repeatedly over the past few hundred thousand years in response to climate change.
- there is a striking biogeographical 'divide' between the biota of the Antarctic Peninsula and that of the rest of the continent, suggesting that the biota does not have a 'recent' origin.
- evidence of rapid water movement beneath ice sheets suggests that subglacial hydrologic systems exist beneath the polar plateau and may link subglacial lakes.
- conjugate studies of aurora showed that the onsets of simultaneous Arctic and Antarctic substorm onsets are not symmetric, which has implications for predicting space weather events that could have deleterious technological impacts.

1. ABOUT SCAR (for further details see www.scar.org)

1.1 Aims and Objectives

SCAR, the Scientific Committee on Antarctic Research, is the principal non-governmental organization responsible for the international coordination of scientific research taking place in the Antarctic region. SCAR is an Interdisciplinary Body of the International Council for

Science (ICSU). ICSU began coordinating scientific research in Antarctica during the International Geophysical Year of 1957-58, and formed SCAR in 1958 to continue the work. The need for such coordination has grown as the role of Antarctica in the global system has become apparent, and continues unabated as we approach the International Polar Year (IPY) of 2007-2008, in which SCAR is playing a leading role, and which is led by ICSU and the World Meteorological Organisation (WMO). SCAR's membership includes 34 nations and 8 of ICSU's Scientific Unions, which link SCAR to a wide range of scientific activities.

SCAR aims to improve understanding of the nature of Antarctica, the role of Antarctica in the Earth System, and the effects of global change on Antarctica. Its main objectives are:

- to initiate, develop, and co-ordinate high quality international scientific research in the Antarctic region, and on the role of the Antarctic region in the Earth system;
- to provide objective and independent scientific advice to the Antarctic Treaty Consultative Meetings and other organizations on issues of science and conservation affecting the management of Antarctica and the Southern Ocean.

To meet these objectives SCAR carries out a comprehensive programme of coordinated scientific research that adds value to national research in the Antarctic by enabling national researchers to work together on major issues of pan-Antarctic scale and having global reach. In addition it provides independent scientific advice, as an official Observer, to three intergovernmental bodies having responsibilities in the Antarctic region:

- the Antarctic Treaty System through the Antarctic Treaty Consultative Meeting (ATCM) and the Committee for Environmental Protection (CEP);
- the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and its Scientific Committee;
- the Advisory Committee of the Agreement on Conservation of Albatrosses and Petrels (ACAP).

1.2 Highlights of 2006

SCAR's XXIXth meeting and 2nd Open Science Conference, hosted by the Australian Antarctic Division in Hobart in July 2006, attracted some 850 participants from 32 countries. Delegates elected three new members – Denmark, Portugal and the International Union for Quaternary Science (INQUA). Bulgaria and the Ukraine moved from Associate to Full membership. At the meeting three SCAR medals were presented: to Peter Barrett (NZ) for outstanding achievement in Antarctic Science; to Paul Mayewski (USA) for excellence in Antarctic research; and to David Walton (UK) for international scientific coordination. SCAR signed a Letter of Agreement with the International Arctic Science Committee (IASC) to promote bipolar research. Planning began for SCAR's XXXth meeting, which is scheduled to take place in 2008 in Russia, with the Open Science Conference in St Petersburg from July 8-11, and the Delegates meeting in Moscow from July 14-16. SCAR and IASC will co-organise the 2008 Open Science Conference.

2. SCAR SCIENCE

2.1 Major Scientific Research Programmes

SCAR has focused its efforts on its five major Scientific Research Programmes (SRPs), each having a bearing on some key social issue, or addressing a frontier of science:

- Antarctica and the Global Climate System (AGCS), a study of the modern ocean-atmosphere-ice system;
- Antarctic Climate Evolution (ACE), a study of climate change over the past 34 million years since glaciation began
- Evolution and Biodiversity in the Antarctic (EBA), a study of the response of life to change;
- Subglacial Antarctic Lake Environments (SALE), a study of lakes buried beneath the ice sheet;
- Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research (ICESTAR), a study of how the Earth's outer atmosphere responds to the changing impact of the solar wind at both poles.

Project Implementation Plans are available from the SCAR website. Main advances in 2006 are described below. SCAR welcomes the involvement of scientists in these programmes (enquiries to infor@scar.org), which contribute to the work of the Parties to the Antarctic Treaty, to CCAMLR and to the UN Framework Convention on Climate Change.

Earth System science tells us that everything is connected. To ensure that we have the interdisciplinary connections we need to address key scientific questions effectively, the leaders of SCAR's 5 Scientific Research Projects and the Chief Officers of SCAR's Standing Scientific Groups for the Life Sciences, Physical Sciences and Geosciences meet twice a year to explore cross-linkages. The last such meeting was in Rome (November 6-8, 2006).

2.1.1 Antarctica in the Global Climate System (AGCS)

AGCS uses meteorological, oceanographic and glaciological data, including records from deep and shallow ice cores covering the past 10,000 years, plus the output of global and regional coupled atmosphere-ocean-ice climate models, to understand Antarctica's role in the Earth's climate system, and how the climate of the Antarctic and the high southern latitudes will evolve over the next 100 years in response to natural and human forcing. Outputs will include an improved understanding of the complex interactions between the atmospheric, oceanic and cryospheric elements of the climate system in the polar regions, of natural climate variability as opposed to human influence in the polar regions, and of how signals of tropical and mid-latitude climate variability reach the Antarctic, and high latitude climate signals are exported northwards. This work on the "modern" climate system complements that on the past climate system by SCAR's ACE programme (section 2.1.1). AGCS and its various sub-programmes (http://www.antarctica.ac.uk/met/SCAR_ssg_ps/AGCS.htm.) are co-sponsored by SCAR and the World Climate Research programme (WCRP).

2.1.1.1 Progress

The AGCS community made a number of significant advances in 2006. A major warming of the Antarctic winter troposphere was discovered from analyses of balloon-launched radiosonde data. The warming is largest 5 km above sea level where temperatures have

increased at a rate of 0.5 – 0.7°C over the last 30 years. It is larger than any previously identified regional tropospheric warming on Earth. Work continues to find a cause.

An analysis of recent trends in Antarctic snow accumulation showed that over the continent as a whole the annual trends are small and not statistically different from zero, suggesting that recent Antarctic snowfall does not affect sea level.

Recent data show that the surface ocean west of the Antarctic Peninsula, where air temperatures rose 3°C since 1951, has become more saline and warmed by more than 1°C in the summer. These changes, driven by atmospheric warming and reduced rates of sea ice production, will further accentuate warming in the region, and will have a deleterious effect on the production of krill and the rest of the Southern Ocean food web.

Modelling shows for the first time that the major, near-surface increase in summer temperature on the eastern side of the Antarctic Peninsula has been caused, at least in part, by increases in global warming. Over the last few decades global warming has shifted the Southern Hemisphere Annular Mode (SAM) into its positive phase during the summer, lowering atmospheric pressure over the Antarctic and increasing it at mid-latitudes. This has strengthened the westerly winds around the Antarctic, bringing mild, maritime air masses across the Antarctic Peninsula to help the disintegration of the ice shelves there.

A study using output from the latest generation of climate models has found that they reproduce the observed mid-depth Southern Ocean warming of 0.2°C that has occurred since the 1950s if they include time-varying changes in anthropogenic greenhouse gases, sulphate aerosols and volcanic aerosols in the Earth's atmosphere. The agreement between observations and climate models suggests significant human influence on Southern Ocean temperatures. Climate models that do not include volcanic aerosols produce mid-depth Southern Ocean warming that is nearly double that produced by climate models that do include volcanic aerosols. This implies that the full impact of human-induced warming of the Southern Ocean has yet to be realized.

Ice core reconstructions of past atmospheric circulation suggest that modern atmospheric circulation intensity is within the range of variability of the last 1000 years. Ice core records also reveal increased penetration of marine air masses into the western coastal regions of West Antarctica in the 1940s.

Analysis of the output from the 20 climate models used in the 4th Assessment of the Intergovernmental Panel on Climate Change (2001) have been used to examine how the climate of the Antarctic will evolve in the 21st Century. The model fields were weighted according to their level of skill in reproducing the climate changes observed over the last few decades. The projections suggest that near surface temperatures in the sea ice zone will increase in winter by up to 0.6°C/decade, resulting in a decrease of 25% in sea-ice cover; central Antarctica will warm at 0.4°C/decade in all seasons; precipitation will increase by 3.3mm/decade on average over the continent, mostly around the edges; westerly winds will strengthen over the ocean, mostly in autumn, but coastal easterlies will decrease; katabatic winds will decrease slightly as polar plateau temperatures rise by several degrees.

AGCS has also been actively coordinating cross-disciplinary Antarctic science and the preparation of data sets and research tools. In April 2006 a workshop was held in Cambridge, UK to consider the strength and weaknesses of the high latitude elements of the atmospheric re-analysis data sets, which are proving a very powerful tool for the investigation of recent climate change. Means were also considered for the collection and digitisation of historical Antarctic meteorological observations for the next round of reanalyses that are to be produced. Several presentations on aspects of AGCS atmosphere, ocean and ice core science were made at the SCAR Open Science Conference (Hobart,

July 2006), where an interdisciplinary AGCS/ACE/EBA workshop was held on "Atmospheric, Oceanic, Cryospheric and Biological Variability Over Decadal to Millennial Timescales".

2.1.1.2 Plans

The second workshop on Recent High Latitude Climate Changed will be held in October 2007 in Seattle, USA. This workshop, which is being organised in conjunction with WCRP's Climate and Cryosphere (CliC) programme and the International Arctic Science Committee (IASC), will consider atmospheric, oceanic and cryospheric changes that have taken place during the last 50 years in the Arctic and Antarctic. AGCS is also involved in the development of plans for key observing systems that will contribute to the Global Earth Observing System of Systems (GEOSS); they include a bipolar cryosphere observing system, and a Southern Ocean Observing System (SOOS).

2.1.2 Antarctic Climate Evolution (ACE)

The Antarctic ice sheet has existed since around the Eocene-Oligocene boundary 34 Ma ago. Its considerable fluctuations have been one of the major driving forces for changes in global sea level and climate to the present time. ACE is collecting and analysing geological data from selected time periods and integrating them with the results of advanced numerical models to establish the origin of the present configuration of the ice sheet and to assess the rates at which it grows and decays over time, as the basis for improving forecasts of the behaviour of the ice sheet, and hence sea-level, through time.

2.1.2.1 Progress

Through the efforts of ACE and its predecessor programme ANTOSTRAT, we now understand that the onset of glaciation was not simply a response to the thermal isolation of Antarctica by the opening of the Southern Ocean between Antarctica and adjacent continents. Recent numerical modelling suggests that declining atmospheric CO₂ was a more important factor in cooling Antarctica. Ice was, however, around before the mid-Cenozoic; marine sediments from Seymour Island provide indirect evidence, from what appear to be drop stones from icebergs, for extensive ice cover in Antarctic near the Cretaceous-Tertiary boundary 65 million years ago.

In the Lambert-Amery glacier-ice shelf region, the field evidence favours a much thinner ice sheet than models show for the last glacial maximum 20,000 years ago. Drilling through the Ross Sea ice shelf shows that the shelf has come and gone repeatedly over the past few hundred thousand years in response to climate change. Both Ross Sea drilling and Lambert Glacier studies confirm that the ice margin has advanced and retreated many times during late Cenozoic times and into the Quaternary, confirming suspicions that fluctuations in the ice sheet reflect changes in insolation driven by changes in the Earth's orbit. Careful examination of the timing of events associated with the Last Glacial Maximum 20,000 years ago now show that the ice sheet retreated rapidly over a period of around 800 years, apparently contributing to a global meltwater pulse as well as to a rapid rise in sea-level.

In 2005/6, ACE members undertook a field campaign led by the British Antarctic Survey, to map, describe, sample and photograph glacial sedimentary sequences and associated fossils on James Ross Island. The rock and fossil samples will be analysed to create realistic environmental reconstructions and new data on environmental change, particularly Antarctic ice sheet history, over the past 7-10 million years, for input to climate models. ACE members also helped prepare the International Ocean Drilling Programme (IODP) Wilkes Land drilling proposal, which is now in the IODP drilling schedule for Austral summer 2008-2009. ACE also helped to develop the IODP Ancillary Program for obtaining a Holocene ultra-high resolution record of climate variability from the Adelie Drift (Wilkes Land).

ACE also influences progress by organising international workshops to highlight particular aspects of Antarctic climate evolution, and publishes the papers as special issues of international journals. The third such issue was published in 2006 (Barrett, P., Florindo, F. and Cooper, A. (Editors) (2006). "Antarctic Climate Evolution - view from the margin". *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol 231, 1-252). It covers a wide range of techniques and timeframes concerning the evolution of the Antarctic continental margin, ranging from detailed sedimentary analyses of the Cape Roberts Project core to numerical modelling investigations of ice sheet growth and decay.

ACE organised two international meetings in 2006: (i) April 2006, EGU, Vienna: "Deep Time Perspectives on Climate Change: Marrying the Signal from Computer Models & Biological Proxies". This session discussed the relevance of pre-Quaternary data to scenarios for future climate change (ii) December 2006, fall AGU, San Francisco: "Post IPY geophysical exploration of Antarctica". This special session brought together experts from the area of radio-echo sounding, who spoke about the development and use of this technique in the exploration of Antarctica over the last 50 years. The session also detailed new ways in which the technique can be developed, which is of central interest to ice sheet modellers as it provides the only feasible means by which sub-ice bed topography can be measured). ACE also contributed a keynote talk on ACE at II Simposio Latinoamericano Sobre Investigaciones Antárticas y VI Reunion Chilena de Investigacion Antartica, Concepcion, Chile, 16-18 August 2006. The ACE website is at www.ace.scar.org.

2.1.2.2 Plans

For 2007, ACE plans to: (i) publish a fourth special issue (in the Journal *Palaeo*, *Palaeo*, *Palaeo*) entitled "Antarctic Cryosphere and Southern Ocean Climate Evolution", with papers from the 2006 EGU ACE session (see above); (ii) support and encourage the ANDRILL programme (drilling in the Ross Sea); (iii) develop an international plan for the collection of airborne and ground-based geophysical data relating to the Antarctic ice sheet (i.e. ice thickness and bed elevation data) in current 'data free' zones and in regions of glaciological change; (iv) plan an ACE modelling workshop for Easter 2008, in which the Antarctic ice volume through the Cenozoic is evaluated; (v) contribute funds and numerous session activities at the International Symposium on Antarctic Earth Sciences (ISAES) meeting at Santa Barbara in August 2007; (vi) organise a session at the INQUA meeting in Cairns, July 2007 on "Climate and ice in Antarctica and the Southern Ocean since the LGM".

2.1.3 Evolution and Biodiversity in the Antarctic (EBA)

EBA's goals are to examine the evolution history of Antarctic organisms, the evolutionary adaptation of organisms to the Antarctic environment, the patterns of gene flow and consequences for population dynamics, the diversity of organisms, ecosystems and habitats in the Antarctic, and the impact of past, current and predicted future environments.

2.1.3.1 Progress

The work on which EBA is based has established that the terrestrial biota of the Antarctic Peninsula is very different from that of the rest of the continent - there is a striking biogeographical 'divide' between the two. This is one of several lines of evidence that suggest that the biota does not have a 'recent' origin. Studies of the evolution of Antarctic organisms imply that there must have been ice-free 'refugia' in which species survived the severe glacial conditions between the warmer interglacials like that we are experiencing today. In the marine realm it has become clear that diversity is high - much higher than expected, and dramatically higher than in the Arctic, with some phyla represented at levels above global averages (e.g. 17.5% of known pycnogonid species; 12.2% of polychaetes; and 8.3% of amphipods). Over the longer term, it can be shown that the evolution of organisms in Antarctica and the Southern Ocean has been influenced first by the creation of

an ocean barrier between Antarctica and other continents around 10-15 million years ago, and second by the formation of the Antarctic Circumpolar Current and its associated frontal systems, especially the Polar Front between 50° and 60°S. Colonisation has been quite different from that in the Arctic where warm conditions brought colonisers from warmer regions. Threats to Antarctic life now come from the invasion of non-indigenous species encouraged by a combination of warming (on the Antarctic Peninsula), the risks of accidental transport through human activity, and the effect of ocean warming on cold-adapted marine animals.

EBA grew out of two major SCAR programmes, RiSCC (Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems), and EVOLANTA (Evolutionary Biology of Antarctic Organisms), both of which ended in 2006. To mark the end of these prior efforts, the RiSCC team produced a synthesis volume (Bergstrom D, Convey P & Huiskes AHL eds., 2006, Trends in Antarctic Terrestrial and Limnetic Ecosystems, Antarctica as a Global Indicator. Springer, Dordrecht, xii + 370 pp.), and the EVOLANTA team produced a number of publications to complement their 2004 special issue of Antarctic Science (volume 16). In addition, the Latitudinal Gradient Programme (LGP), which is linked to EBA, published a special issue of Antarctic Science (volume 18) in December 2006, and EBA members completed the publication of a synthesis volume from the final meeting of the EASIZ (Ecology of the Antarctic Sea Ice Zone) programme (Deep Sea Research II, volume 53, May 2006).

One major contributor to EBA is the Census of Antarctic Marine Life (CAML), a five-year project to investigate the distribution and abundance of Antarctica's marine biodiversity, how biodiversity is affected by environmental change, and how change will alter the nature of the ecosystem services provided to the planet by the Southern Ocean. Although the majority of CAML's fieldwork on around 14 separate ship or cruise activities will occur during the International Polar Year (2007-2008), the first cruise, aboard *Polarstern*, began around the Antarctic Peninsula in December 2006. The CAML Office (www.caml.aq) is hosted by the Australian Government Antarctic Division and funded by the Sloan Foundation.

In parallel with CAML, the IPY programme ICEFISH (International Collaborative Expedition to collect and study Fish Indigenous to Sub-Antarctic Habitats) (www.icefish.neu.edu) will study the dominant suborder Notothenioidei, to help understand the evolution, population dynamics, eco-physiology and eco-biochemistry of these sub-Antarctic fish and their Antarctic relatives. ICEFISH, which contributes to both EBA and CAML, started with a cruise in the South Atlantic sector in 2004 (a special issue of Polar Biology is in press), and will sample the Pacific sector in 2007.

A complementary IPY project "SYstem-Coupling" (SYSTCO) will take a vertical snapshot through the water column to examine atmospheric-pelagic-benthic coupling processes. EBA representatives organised an IPY-SYSTCO workshop at the Alfred Wegener Institute (Bremerhaven, Germany) in September 2006.

Two EBA-coordinated databases meet the needs of EBA and affiliated programmes. One is the RiSCC terrestrial/freshwater database held at the Australian Antarctic Division (<http://aadc-maps.aad.gov.au/aadc/biodiversity/>). The other is the Marine biodiversity portal (MarBIN, <http://www.scarmarbin.be/>), which, with generous help from the Belgian government and the Alfred P. Sloan Foundation, is established at the Royal Belgian Institute of Natural Sciences. Both link to the Global Biodiversity Information Facility (GBIF); MarBIN also links to the Ocean Biogeographical Information System (OBIS).

During 2006, EBA participated in (i) a number of sessions and workshops on EBA, LGP, CAML, RiSCC, EVOLANTA and ICEFISH as part of the SCAR Open Science Conference (Hobart, July 2006); (ii) a workshop on Antarctic terrestrial diversity, held jointly with the

SCAR Antarctic Treaty System Committee and the SSG for Life Sciences (Stellenbosch, October 2006); (iii) the implementation workshop of the Dutch-led “TARANTELLA” IPY programme (Netherlands, October 2006); (iv) a SCAR-MarBIN workshop (Evolution of Marine Organisms of the Southern Ocean) on marine biodiversity (Leuven, December 2006); and (v) meetings of the Malaysian Antarctic Research Programme (Kuala Lumpur, August 2006) and the South American Antarctic Science community (Concepcion, August 2006). The EBA website is hosted at: <http://www.nioo.knaw.nl/projects/scarlsssg/eba/>.

2.1.3.2 Plans

EBA's plans for 2007 include: (i) a joint EBA-MERGE (IPY) session at the Cryosphere Resources Conference (Salekahan, West Siberia); (ii) a joint EBA-ACE session at Antarctic Earth Sciences Symposium (Santa Barbara); (iii) participation in the 3rd Malaysian Antarctic Science conference (March 2007), to engage Asian Antarctic operators, and to advertise SCAR activities to currently non-participant countries; (iv) funding the collation of existing terrestrial biodiversity data and population of terrestrial biodiversity database (through University of Stellenbosch); (v) completing publication of papers from the IX SCAR Biology Symposium (Curitiba) as a special issue of Antarctic Science; and (vi) contributing to planning the 10th SCAR Biology Symposium (2009), and 3rd SCAR Open Science Conference (2008).

2.1.4 Subglacial Antarctic Lake Environments (SALE)

SCAR's SALE programme continues to promote, facilitate, and champion international cooperation and collaboration to explore and study subglacial lakes and streams in Antarctica, following appropriate standards of environmental protection.

2.1.4.1 Progress

We now know that Antarctica has a complex, continental-scale hydrological system comprising interconnected subglacial lakes and streams under thick ice sheets. A recent paper used satellite observations of changes in the height of flat-spots on the ice to deduce that one lake had discharged downstream into another. The existence of sub-ice water was confirmed when drilling to the base of the ice at the Kohnen Station in the EPICA project in January 2006 led to an injection of water into the base of the drill hole from the ice-rock interface – something also seen in Greenland drill holes.

Subglacial water is central to many processes that have shaped the Antarctic continent and its ice sheets today and in the past. Wet subglacial environments are isolated from the weather, the seasons, and celestially controlled climatic changes that establish fundamental constraints on the structure and functioning of most other Earth-bound environments. The processes that affect subglacial environments are mediated by the flow of the overlying ice, by the flux of heat and possibly fluids from the underlying rocks, and by hydrological processes that deliver water, materials, and heat to and through subglacial systems, dictating the residence times of water in lakes. This complex hydrological system constitutes one of Earth's last great unexplored frontiers and can be expected to contain clues to fundamental Earth and life processes. Its study will advance our understanding of how life, climate, and planetary history have combined to produce the Antarctic continent as we know it today.

Major scientific advances in the last year were summarized at the second SCAR SALE workshop (Grenoble, France, April 2006)(see (<http://salepo.tamu.edu/saleworkshop2006>)). The workshop laid out plans for future SALE exploration and study, calling for a continent-wide campaign at multiple locations to: 1) systematically map subglacial lake systems and their environs, and 2) enter, instrument, and sample ice, water, sediments, and potential microbiological residents.

There were several SALE presentations and posters at the Open Science Conference in Hobart in July 2006. The SALE IPY program, SALE -UNITED (Unified International Team for Exploration and Discovery), continues to develop its plans. SALE was a featured programme at the Fall 2006 American Geophysical Union IPY session in December 2006, where SALE investigators also organized a session on sub-ice water. The SALE Programme Office at Texas A&M University (<http://salepo.tamu.edu/>) continues to be the focal point for all SALE related activities, programmes, projects and publications.

2.1.4.2 Plans

The report of the US National Academy's "Committee on Principles of Environmental and Scientific Stewardship for the Exploration and Study of Sub-glacial Lake Environments" will be released early in 2007, and will provide further guidance on the standards needed to responsibly explore these environments. During 2007 there will be several SALE sessions at major meetings, including (i) one or more subglacial environment sessions at the EGU Annual Meeting in Vienna, Austria; (ii) the third SCAR SALE meeting, in Montana, USA; and (iii) a SALE session at the AGU National meeting.

In terms of outreach and communication, SALE-UNITED will be featured in a number of IPY "kick-off" education and public outreach events. SALE is part of an application to US NASA to develop museum and science centre related exhibits and resources during the IPY. A chapter is in progress for a book on polar limnology (Priscu et al.). A SALE brochure is being developed by the SALE Programme Office and will be widely distributed. Finally a feature article is in press in EOS.

2.1.5 Inter-hemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research (ICESTAR)

ICESTAR will create an integrated, quantitative description of the upper atmosphere over Antarctica, and of its coupling to the global atmosphere and the geospace environment.

2.1.5.1 Progress

Highlights include the following: (i) conjugate studies of aurora showed that the onsets of simultaneous Arctic and Antarctic substorms are not symmetric, which has implications for predicting space weather events that could have deleterious technological impacts; (ii) satellite observations suggest that the global rate of merging between interplanetary magnetic fields and Earth's magnetosphere drives near-Earth space weather, which implies that contrary to prevailing wisdom space weather cannot best be predicted by the behaviour of solar wind electric fields.

ICESTAR shares with the International Heliophysical Year (IHY) management of an approved IPY programme no. 63 ("Heliosphere Impact on Geospace"). The scientific goals of the ICESTAR-IHY-IPY programme fall into three main themes:

- Coupling processes between the different atmospheric layers and their connection with the solar activity:
- Energy and mass exchange between the ionosphere and the magnetosphere:
- Inter-hemispheric similarities and asymmetries in geospace phenomena.

Each project in the combined proposal has a set of project-specific scientific objectives, but the interrelationships between the studied processes mean there is significant synergy between them. As a result the overall proposal will be able to address topics with far-reaching scientific impact that are important to society at large. One practical benefit will be improved prediction of space weather phenomena that adversely affect spacecraft

operations, humans in space, and satellite-based positioning systems. On the scientific side, global-scale coordination of observing networks will allow us to study conjugate and multi-scale geospace phenomena in fundamentally new ways. Concrete work on linking the IHY, IPY and ICESTAR research activities took place in October 2006.

In the first ICESTAR workshop (Toulouse, July 2005) data sharing issues were discussed for the first time among a wider community including representatives of some of the most widely used existing geospace data servers. The group agreed to focus initially on three data servers: VGMO (magnetometer data), GAIA (auroral precipitation data), and Madrigal (Incoherent scatter radar data), and to build or upgrade these systems so that they have easily adoptable interfaces for both users and data providers. A more ambitious goal will be to make the systems communicate electronically.

The GAIA Virtual Observatory (VO) is presently being developed by research groups at the University of Calgary, Lancaster University, and the Finnish Meteorological Institute, and a prototype of the VO for optical data (browser for quick-look data) was released (see <http://gaia-vxo.org>). Plans are being made for the final system. A prototype of the VO for magnetometer data, VGMO.NET, was released in 2005 - see the 2005 Annual Report, and also see *A Virtual Global Magnetic Observatory: VGMO.NET*, Papitashvili, V. O., A. B. Saxena, V. G. Petrov, C. R. Clauer, and N. E. Papitashvili, *Earth, Planets and Space*, 58, No. 6, 765-774, 2006.

2.1.5.2 Plans

The kick-off meeting for the ICESTAR/IHY IPY programme on Heliosphere Impact on Geospace (Helsinki, February 5-9, 2007) will lead to publication in early 2008 of a special issue on this topic in the *Journal of Atmospheric and Solar-Terrestrial Physics*. During 2007/8 the multidisciplinary IPY project POLENET (meteorology, glaciology, volcanology, seismology) will build and maintain an extensive Antarctic network of dual-frequency GPS receivers. Data from this network will be invaluable for the ICESTAR-IPY community, which also maintains several GPS receiver stations in the Antarctic for ionospheric research. The POLENET and ICESTAR communities will collaborate on the development of GPS data sharing systems. A dedicated Working Group with POLENET, ICESTAR, and SSG-GS representatives will start the preparatory work in early 2007.

2.2 Specific Research Areas

2.2.1 Life Sciences Group

The Standing Scientific Group for the Life Sciences (SSG-LS) is responsible for a number of other activity areas aside from EBA. Among its activities for the year were:

- the start of planning for the 10th SCAR Biology Symposium, which will be held in Sapporo, Japan, in 2009; this will be the first SCAR Biology Symposium in Asia.
- the Expert Group on Birds continued to provide advice regarding the nomination of Specially Protected Species status to Southern Giant Petrels. The Group continues to work with BirdLife International to define Important Bird Areas in the Southern Ocean region, and continues its assessment of the potential impact of flipper banding on penguins.
- the Expert Group on Seals completed the final report of the Antarctic Pack Ice Seals (APIS) project. A new research programme is being designed to understand the role(s) of top predators in the Southern Ocean. It will integrate long-term studies with new animal-borne instrument technologies for the study of water masses, behaviour and movement patterns.

- the Life Sciences SSG is considering the options for a potential merger of the Expert Groups in Birds and Seals to form a new Expert Group on Higher Predators, and will report on progress to the Executive Committee in July 2007.
- the Expert Group on Human Biology and Medicine has started having annual meetings with the Medical Network (MEDINET) group of COMNAP (Council of Managers of National Antarctic Programmes).
- in response to questions about Antarctic Conservation in the 21st Century, the Life Sciences SSG organised a workshop in Stellenbosch, South Africa. Following initial discussions it became clear that in order to address this issue adequately the scope of the effort should be expanded to include the World Conservation Union (IUCN).
- at the SCAR scientific meeting in Hobart (July 2006) the Life Sciences SSG established a new Action Group on Continuous Plankton Recorder (CPR) research, and endorsed the already existing CPR data set as a SCAR data set. Extensive CPR data will be collected during the IPY. The CPR-AG will work closely with CAML, EBA and SCAR-MARBIN.
- SCAR continued its co-sponsorship of both the Southern Ocean programme of the Global Ocean Ecosystems Dynamics (GLOBEC) project of the International Geosphere-Biosphere Programme (IGBP), and of a new programme by the name of Integrated Climate and Ecosystems Dynamics (ICED), which is also part of IGBP. ICED set up a website (<http://www.antarctica.ac.uk/Resources/BSO/ICED/index.htm>) and circulated a draft science plan for comment.

2.2.2 Geosciences Group

The Standing Scientific Group for the Geosciences (SSG-GS) contains several Expert and Action Groups aside from ACE and SALE. Reports on the activities of selected Expert and Action Groups follow:

- The Marine Acoustics Action Group produced a new report on the impacts of acoustic technologies on cetaceans, which was presented to and well received by the 29th ATCM meeting in Edinburgh (June 2006). A new Action Group – on Sub-Ice Geological Exploration (SIGE), was formed to look into ways of developing a collective SCAR-wide pan-Antarctic approach to drilling into the rocks beneath the ice to improve our understanding of Antarctica's geological history.
- Planning has begun for the 10th International Symposium on Antarctic Earth Science (ISAES) (Santa Barbara, California, August 26 through September 1, 2007).
- High quality bathymetric maps are needed for safe navigation, as input for ocean modellers, to provide information on ecosystems, and as a clue to geological processes. The Expert Group on the International Bathymetric Chart of the Southern Ocean (IBCSO) aims to produce a high-resolution bathymetric map of the Southern Ocean as a contribution to the General Bathymetric Chart of the Oceans (GEBCO). The work is shared with the Intergovernmental Oceanographic Commission (IOC) and the International Hydrographic Office (IHO). It ramped up in mid-October 2006 with employment of an IBCSO scientific editor at the Alfred Wegener Institute (AWI). During the year, multi-beam bathymetric data were collected and processed on four *Polarstern* cruises in Antarctic waters, and submitted a bathymetry proposal (POBACE) to the IPY Project Office. During 2007, IBCSO will combine bathymetric data from the Weddell Sea, the Ross Sea and the Indian Ocean, including multi-beam data from ships and ETOPO2v2 data from satellite altimetry. Progress, plans and requirements will be discussed at an IBCSO session during the ISAES meeting in Santa Barbara (September 2007). See www.awi-bremerhaven.de/GEO/Bathymetry/ibcso/, the IBCSO website, for further information.

Both SCAR and the Scientific Committee on Oceanic Research (SCOR) strongly support efforts to gather and make available bathymetric data from sparsely surveyed areas of the Southern Ocean. At a meeting in London in December 2006, SCOR recommended (i) that Principal Investigators (PIs) should incorporate into their proposals requests to collect and process multi-beam bathymetric data, especially data that fills present gaps; (ii) that funding agencies should fund multi-beam bathymetry data acquisition and processing on all research vessels equipped with multi-beam echo-sounders, whether on transit or on location; and (iii) that PIs should submit their data to the appropriate World Data Centre (US National Geophysical Data Centre – NGDC).

- The Expert Group on Geodetic Infrastructure of Antarctica (GIANT) provides a common geodetic reference system for all Antarctic scientists and operators. It also contributes to global geodesy for studying the physical processes of the earth and the maintenance of the precise terrestrial reference frame, and provides information for monitoring the horizontal and vertical motion of Antarctica. Together with SCAR's Antarctic Neotectonics (ANTEC) Expert Group, GIANT is a leader in the bipolar IPY POLENET (Polar Earth Observing Network) project, to which GIANT will contribute the Antarctic GPS component. During the year ANTEC organised an EGU symposium on short and long-term observations in the polar regions (April 2006) and GIANT organised a POLENET workshop (Dresden, October 2006). For more information see: <http://www.geoscience.scar.org/geodesy/giant.htm>.
- At the XXIX SCAR meeting in Hobart 2006, the Expert Group on Geographic Information (EGGI) was repositioned from within the Standing Scientific Group for the Geosciences to become the Standing Committee on Antarctic Geographic Information (SC-AGI). SC-AGI provides geographic information products and policies to support Antarctic science and operations; integrates and coordinates Antarctic mapping and Geographical Information System (GIS) programmes; promotes an open standards approach to support free and unrestricted data access; and promotes capacity building towards sound Antarctic geographic data management. Its work helps to provide geographic limits to Antarctic Specially Protected Areas (ASPAs) and Antarctic Specially Managed Areas (ASMAs), and geospatial web services that might be needed for scientific, logistic, or tourism-related applications. SC-AGI aims to create an Antarctic Spatial Data Infrastructure (AntSDI). During 2006, a SC-AGI workshop was held in Hobart in July (see <http://www.antsdi.scar.org/eggi/meetings/>).

A range of SC-AGI geographic information products is available as follows:

- Place Names: The SCAR composite gazetteer (http://www3.pnra.it/SCAR_GAZE). SCAR Map Catalogue: (<http://aadc-maps.aad.gov.au/index.cfm>) Topographic Database: The Antarctic Digital Database (ADD) at: <http://www.add.scar.org/>.
- The SCAR King George Island Geographical Information System (KGIS): <http://www.kgis.scar.org/>
- The Cybercartographic Atlas of Antarctica: <http://www.carleton.ca/gerc/caap>.
- The SCAR Feature catalogue: <http://aadc-maps.aad.gov.au/aadc/ftc/index.cfm>.
- The Antarctic Digital Magnetic Anomaly Project (ADMAP) aims to map Antarctica's magnetic anomaly field to aid in understanding geological processes. It is managed jointly with IAGA (International Association of Geomagnetism and Aeronomy). ADMAP contributes data to the World Magnetic Anomaly Map (for details see: <http://www.geology.ohio-state.edu/geophys/admap>). During 2006, ADMAP developed a DVD of the compilation of data up to year 1999 for release to the World Data Centers; updated near-surface anomaly predictions; improved modeling of the Antarctic core field and its secular variations; compiled rock magnetic and other

physical properties into a database to support geological applications; and developed and promoted regional and continental scale interpretation of the ADMAP data. In 2007, ADMAP will continue compiling all available terrestrial, marine, and satellite magnetic survey data collected since the IGY 1957-58 for the region south of 60°S, incorporating new magnetic surveys into the ADMAP digital database. SCAR will fund a workshop to formally release the database to the World Data Centers. ADMAP will continue developing and promoting regional and continental scale interpretation efforts and help identify areas for new collaborative magnetic surveys.

- The Expert Group on Antarctic Permafrost and Periglacial Environments (EGAPPE) provides coordination, communication and exchange of data amongst Antarctic permafrost researchers within SCAR and the International Permafrost Association (IPA). It works closely with the IPA working group on Antarctic Permafrost and Soils. The activities of both are described under the acronym, ANTPAS, the Antarctic Permafrost and Soils group (see <http://erth.waikato.ac.nz/antpas/>). During 2006 the ANTPAS submission to IPY was approved by the IPY Joint Committee. A network of data centres was identified for managing ANTPAS data; soil maps are being prepared for Antarctic dry valleys; and a set of latitudinal environmental gradients was identified for monitoring change. In July ANTPAS held its second meeting in Hobart. The journal, *Geoderma*, approved production of a special issue entitled “Antarctic Soils and Soil-Forming Processes in a Changing Climate”, to be edited by Jim Bockheim. During 2007, EGPPS will (i) obtain standardized permafrost temperature and active layer measurements across all permafrost regions; (ii) revise estimates of carbon pools in permafrost regions; (iii) establish a periglacial monitoring network; (iv) improve regional permafrost mapping; (v) and develop and promote permafrost information and educational activities.

2.2.3 Physical Sciences Group

The Standing Scientific Group for the Physical Sciences (SSG-PS) reported a number of highlights.

- The plateau astronomy group was dissolved, having achieved its objective in demonstrating that the Antarctic Plateau is the best place on Earth for surface-based astronomy – future plans call for possible installation of a terahertz telescope at Dome A, and a 2.4-metre optical/infra-red telescope at Dome C.
- The working group on katabatic winds held a workshop on the Antarctic wind field, which produced a report assessing our understanding of the near-surface flow across the continent. The katabatic winds group was absorbed into AGCS (see above).
- At its meeting in Hobart in July 2006, recognising that separating natural from human induced variability in the Antarctic is a major challenge that requires sustained observation of multiple parameters, the SSG created a new Action Group for a Pan-Antarctic Observations Network (PANTOS). Some aspects of sustained observations are already being addressed by ongoing ocean and cryosphere activities (see below), which can be coordinated by PANTOS.
- As another means of accessing information about climate change, the SSG endorsed SCAR’s co-sponsorship of the International Partnership in Ice Core Science (IPICS), which deals with the science emerging from drilling long ice cores from the polar ice caps.
- The SSG endorsed plans to develop a review of ‘Antarctic Climate Change and the Environment’, which will be led by AGCS.

- The SSG agreed that the Antarctic Astronomy and Astrophysics Expert Group should develop plans for a Scientific Research Project on Astronomy and Astrophysics.
- The SCAR/SCOR Oceanography Expert Group (EG-OCEAN) continued its work to encourage an inter-disciplinary approach to Southern Ocean observations, modeling and research; to facilitate coordination between the physical oceanographic research groups currently active and those planning research in the Southern Ocean; to identify historical and reference data sets; and to encourage the exchange of information with operational agencies. EG-OCEAN held its second meeting, in Hobart (in July), and agreed to focus on developing plans for a Southern Ocean Observing System (SOOS). A workshop on that topic, organised by SCAR, CAML and the Partnership for Observations of the Global Ocean (POGO), took place on July 15 in Hobart, and led to the formation of a Scientific Organizing Committee for a SOOS workshop to be held in Bremen in October 2007.

SCAR also co-sponsors with CLIVAR and CliC the Southern Ocean Implementation Panel (SOIP), which is devoted to establishing a Southern Ocean observing system, and the International Programme for Antarctic Buoys (IPAB), which deploys drifting buoys on the sea ice. The SOIP met in Buenos Aires on 14 -15 November to discuss progress and plans for Southern Ocean observations, and IPAB met in Hobart in July. These various groups are all involved in developing leading IPY projects.

- SCAR continued to work with WCRP to develop a Bipolar Cryosphere Observing System for the Integrated Global Observing System Partnership (IGOS-P). A blueprint has been developed of requirements for cryospheric observations from space and in situ that are needed to document cryospheric change (<http://stratus.ssec.wisc.edu/igos-cryo/>). Space agencies and others will implement the requirements as part of the Global Earth Observing System of Systems (GEOSS). SCAR will take responsibility for monitoring progress in implementing the system in Antarctica.
- The SCAR Expert Group on Ice Sheet Mass Balance and Sea Level (ISMASS) aims to revitalize approaches to assessing methods and uncertainties in estimating Antarctic Ice Sheet mass balance and its relation to sealevel. Many recent events suggestive of rapid ice-sheet change cannot be reproduced by the current generation of whole ice-sheet models on which the predictions issued by the IPCC are primarily based. Developing the next generation of more realistic ice-sheet models requires a comprehensive and integrated approach based on targeted data collection and interpretation, and theoretical and numerical developments. ISMASS is developing plans to work on these issues with the NSF-supported Center for Remote Sensing of Ice Sheets (CReSIS), led by the University of Kansas, and the Center for Interglacial Climate at the Niels Bohr Institute at the University of Copenhagen.

ISMASS plans to convene a town-hall meeting during the IUGG meeting in Perugia (July 2007) to assess progress and to develop plans for the next 5-10 years, and to organise a joint ITASE/ISMASS/AsPECT symposium for the SCAR meeting in St. Petersburg (2008).

3. DATA AND INFORMATION MANAGEMENT

One of SCAR's goals is to facilitate free and unrestricted access to Antarctic scientific data and information in accordance with article III-1c of the Antarctic Treaty. This is the task of the Joint SCAR-COMNAP Committee on Antarctic Data Management (JCADM) (<http://www.jcadm.scar.org>).

During the reporting period:

- JCADM has succeeded in involving more National Antarctic Data Centres (NADCs), in training NADC operators, and in increasing the population of the Antarctic Master Directory (AMD) with metadata.
- the AMD now contains over 4000 data set descriptions, many of these directly linked to online data. 23 nations now contribute to the AMD, which is being accessed increasingly by the wider community.
- JCADM is now much more engaged with the scientific community, through attending meetings of the Chief Officers of the SSGs, by adding a JCADM representative to the Steering Committee of each Scientific Research Project (SRP), and by making presentations to and listening to the requirements of the SSGs and SRPs during their meetings in Hobart (July) and Rome (November).
- JCADM's performance was reviewed by a Standing Committee on Antarctic Data Management (STADM), and found very favourable.
- JCADM's Terms of Reference were revised and approved by the SCAR and COMNAP Delegates meeting in Hobart in July.
- JCADM is engaged in developing the IPY scheme for data management, and will develop a SCAR data and information strategy.

4. INTERNATIONAL POLAR YEAR

SCAR is making a significant contribution to the proposed International Polar Year (IPY)(2007 – 2009). Both the new SCAR President and the SCAR Executive Director are members of the Joint ICSU/WMO Committee for the IPY, which also contains several scientists eminent in SCAR science programmes. During 2006, these people contributed to the writing of 'The Scope of IPY Science', which will be published early in 2007. They also contributed to the process for final approval of the 228 proposals covering the Arctic or Antarctic or both. SCAR is either leading or involved in 70% of the Bipolar or Antarctic natural science projects approved by the IPY Joint Committee. SCAR's 5 scientific research programmes lead project clusters for the IPY, and the Chief Officer of JCADM is contributing as co-chair of the IPY Data and Information Management Subcommittee. Principal Investigators are now applying to their national committees for funds. SCAR has begun considering the question of how to manage the IPY legacy once the IPY is over. Among other things, SCAR would expect to retain responsibility for IPY Antarctic data and information management, through JCADM, and to be responsible for specific observing systems, such as the Southern Ocean Observing System and the Antarctic part of the Cryosphere Observing System, both of which are being developed through the IPY. The first formal IPY conference will be the Joint SCAR/IASC Open Science Conference in t Petersburg (8-11 July 2008) on: Polar Research – Arctic and Antarctic Perspectives in the International Polar Year.

5. SCIENTIFIC ADVICE TO ATCM, CEP, CCAMLR AND ACAP

Through its status as Observer, SCAR continues to be the primary source of independent scientific advice to the Antarctic Treaty Consultative Meeting (ATCM) and the Committee on Environmental Protection (CEP). SCAR participated in the XXIXth ATCM in Edinburgh (June 2006). The SCAR Lecture, on 'Climate Change – an Antarctic Perspective' by Valerie Masson-Delmotte (Fra.), was very well received. SCAR presented 4 Working Papers and 6 Information Papers. The Working Paper on the delisting of Fur Seals was accepted; that on

the listing of the Giant Petrel was returned at SCAR's request for further work. SCAR is proposing to provide up to 7 Working Papers and 5 Information Papers for the XXXth ATCM in Delhi in May 2007.

Following the Edinburgh ATCM, David Walton (UK), the chair of SCAR's Standing Committee on the Antarctic Treaty System (SC-ATS), retired to be replaced by Prof Steve Chown (RSA). Heinz Miller (Ger.) also joined the Committee.

SCAR is also an Observer to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Colin Summerhayes (SCAR) and Graham Hosie (Australia) - represented SCAR at the 25th annual CCAMLR meeting in Hobart (October 2006). Several of SCAR's marine biology programmes provide strong links to CCAMLR's interests, especially SCAR's Census of Antarctic Marine Life (CAML) programme, the SCAR Continuous Plankton Recorder (CPR) programme, EBA, and SCAR's Marine Biodiversity Information Network (MarBIN). The work of SCAR's Ocean Expert Group is also relevant to CCAMLR, as is that of our expert groups on birds and seals. SCAR is assisting CCAMLR in developing the concept of bioregionalisation of the Southern Ocean.

Recognising the expertise of the SCAR Bird Group, SCAR is an Observer at meetings of the Advisory Committee on Albatrosses and Petrels (ACAP), providing advice and data on the distribution, abundance, population trends and regional conservation status of Southern Giant Petrels. SCAR was unable to attend the ACAP meeting in Brazil in June, but did submit an Information Paper on Marine Protected Areas.

6. OTHER DEVELOPMENTS

The SCAR History Group is investigating the drivers for scientific research in the Antarctic. It met in Santiago, Chile (September 2006), to discuss "Multidimensional exploration of Antarctica around the 1950s". Holding the meeting in South America facilitated the participation of colleagues from the region and opened the discussion on the history of Antarctic research to scholars of countries neighbouring Antarctica. A follow-up meeting on "National and transnational agendas in Antarctic Research from the 1950s and beyond" will be held at Byrd Polar Institute, Columbus, USA, in October 2007.

SCAR published in SCAR Report 28 its plans for a Capacity Building, Education and Training (CBET) programme, especially for the benefit of those SCAR Members and others with limited experience of working in the Antarctic region. As part of that programme, SCAR operates a Fellowship Programme (5 Fellows funded in 2006-2007). SCAR and its partner the International Polar Foundation succeeded with their bid for an IPY programme on capacity building in Antarctic research ('The 6th Continent Initiative'). Finally, SCAR became an Associate Member of the International Antarctic Institute, which is a "virtual" university comprising the Antarctic science courses of a number of universities and institutes around the world, led by the University of Tasmania.

In the Secretariat, Mrs Karen Smith was appointed as the new Administrative Assistant, operating part-time from the end of January 2006.

SCAR's communications continued to be focused through the SCAR website, especially the SCAR quarterly Newsletter. There were on average 83620 hits per month on the SCAR website for the 5 months after the Hobart conference, which is an 18% increase over the same period in 2005 (68820), and a 57% increase over the same period in 2004 (36020). In May, just before the conference, hits rose to 115300.